Habitat Value of Natural and Constructed Wetlands Used to Treat Urban Runoff

Literature Review Findings , Research Gaps, and Recommendations to Enhance Habitat Value

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State Coastal Conservancy Seeks to Resolve Uncertainties and Open Dialogue on this Issue

- Step 1: Establish baseline of science and regulatory context
- Step 2: Foster interagency coordination
- Step 3: Conduct public outreach
- Step 4: Seek funding to conduct priority research

Literature Review Questions

- Do natural or constructed wetlands used for treatment of urban runoff become hazards for wildlife?
- How does directing urban runoff or stormwater through or a natural or constructed wetland affect the habitat of the wetland?
- To what extent does the intentional manipulation of wetland to maximize water treatment capacity detract from the habitat value of the wetland?
- How does habitat value of treatment wetlands differ by wetland class?

Developing the Literature Review

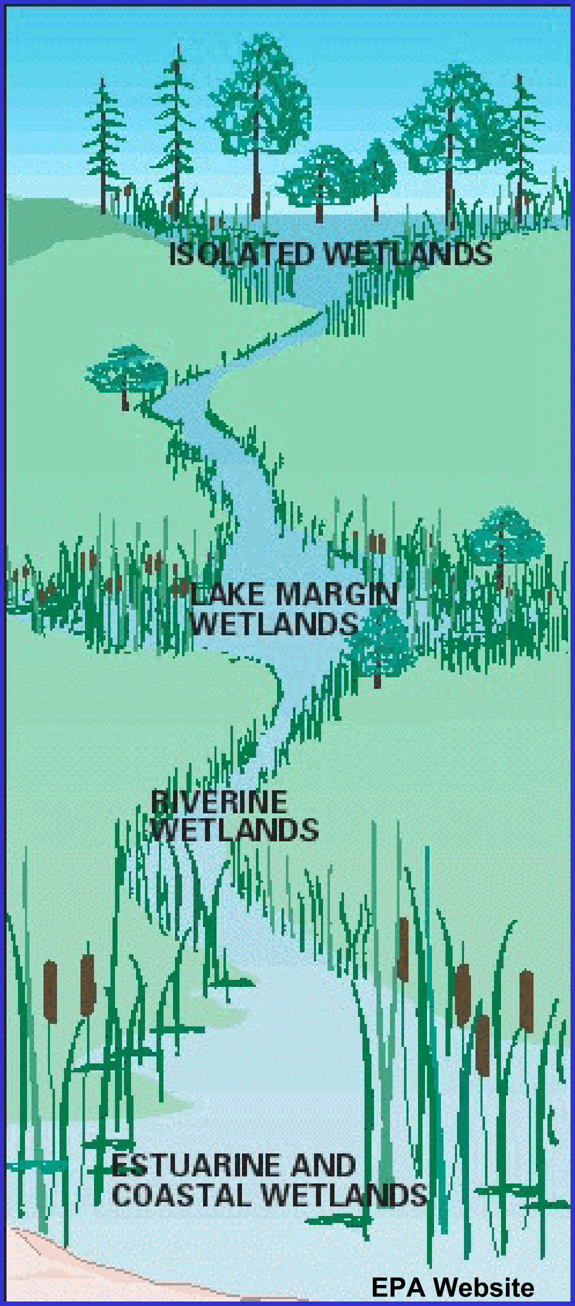
- Review of over 200 peer-reviewed publications and reports
- Peer-reviewed by experts including regional board and resource agency staff

Scope & Organization of Literature Review

- Factors affecting WQ treatment capacity of wetlands
- Potential Impacts on Habitat
- Literature recommendations on siting, design and management criteria to mitigate risk to wildlife
- Research Needs

Literature Review Findings: Big Picture

- Insufficient literature to assess effectiveness of wetlands as urban runoff BMPs
- Adequate research does not exist to address issue of habitat value of treatment wetlands
- Concerns of risk to wildlife are valid and merit further research
- Acute lack of literature in semi-arid or arid climates



Biogeochemical Processes That Control Water Quality in Wetlands Vary by:

- Wetland type
- Position in landscape
- Geology of soils
- Hydrology
- Chemistry of water and soils
- Flora and fauna

Implications….

- Not all wetlands have equivalent treatment capacity

  e.g. Depressional wetlands remove/retain particle-bound contaminants better than riverine wetlands

  - High variability from site to site depending on physical and biological structure of wetland

- Value of habitat can vary greatly depending on wetland class and site-specific factors

  - Don’t over generalize lit review findings-- Adverse effects found in one wetland may be different than found in others

Ecological Engineers Optimize Natural Treatment Capacity of Wetlands By:

- Manipulate hydrology
  - Maximize hydraulic retention time (maximize contact time)
  - Minimize pulsed flows, short-circuiting and “dead spaces”
- Manipulate physical structure
  - Wetland shape,
  - Shallow, vegetated areas versus deeper, open water
- Manipulate wetland biota
  - Composition of vascular plant community
  - Microbial communities (through hydrology)
- Management and Maintenance

Implications.....

- Habitat of treatment wetlands often fundamentally different than that of natural wetlands
- Science of using wetlands to treat urban runoff is still developing
  - Storm & dry weather flows have variable hydrology and contaminant loading = harder to engineer predictable treatment
  - Engineering design guidelines only rule of thumb = more data needed for arid systems
  - Standardized method of evaluating wetland BMP effectiveness needed for Southern California
  - Use conservative hydraulic & contaminant loading rates!!

Examining Impacts of Urban Runoff on Habitat Value of Wetlands

IS THERE A RISK TO WILDLIFE?

Use Ecological Risk Assessment Paradigm…

Exposure + Ecological Effects = Ecological Risk

Examining Impacts of Urban Runoff on Habitat Value of Wetlands

Using Ecological Risk Assessment Paradigm…

- Impacts on Physical Habitat = Exposure
  - hydrology
  - geomorphology and sediment transport
  - sediment and water chemistry
- Impacts on Wetland Biota = Ecological Effects
  - bioaccumulation
  - toxicity
  - species and habitat diversity
  - community and trophic structure

Impacts of Diverting Urban Runoff to Wetlands: Hydrology

- Change in dry season flow – can lead to type conversion of wetlands in some cases
  - Riverine: ephemeral stream ←→ perennial stream
  - Depressional: seasonal wetland ←→ permanent wetland
  - Estuarine: change in salinity and patterns of flow, sedimentation, erosion
- Increased frequency, magnitude, and duration of peak flows
  - Riverine: scouring or excess sedimentation of channel and bank habitats
  - Depressional: larger, more frequent and rapid water level fluctuations can stress vegetation and fauna

Impacts of Diverting Urban Runoff to Wetlands: Water and Sediment Chemistry

Increases observed in….

- Salinity and temperature
- Nutrients and organic carbon
- Heavy and trace metals
- Pesticides and hydrocarbons
- Bacteria

Impacts of Diverting Urban Runoff to Wetlands: Water and Sediment Chemistry

- Nitrogen (N), Phosphorus (P) and Organic Carbon (C)
  - Controls production of plants, algae, and bacteria
  - Feedback loop → pH, dissolved oxygen, sediment redox → controls contaminant cycling in sediments
  - Wetlands are permanent sink for C & N
- Can sustainably assimilate C and N under conservative loading rates
- Overloading …..
  - Excessive aquatic plant and algal growth
  - Low DO and sediment redox → release of sequestered P, metals, and some organic contaminants in sediments
  - Plant, algal & benthic communities shift to stress-tolerant

Impacts on Diverting Urban Runoff to Wetlands: Water and Sediment Chemistry

- Heavy & Trace Metals/Organic Contaminants
  - Concern for bioaccumulation and toxicity
  - Tend to be associated with fine suspended sediments
  - Mechanism for removal = sedimentation and storage in sediments
  - Storage in sediments is not permanent – can be remobilized by change in sediment chemistry, storm event, wind, etc.
  - Literature documents many cases of high sediment metal concentrations in stormwater ponds
  - Fate and transport of organic contaminants poorly studied

Impacts of Diverting Urban Runoff to Wetlands: Water and Sediment Chemistry

- Bacteria
  - Bacteria play an important role in wetland water quality
  - Sedimentation and die-off from sun exposure main mechanisms for removal of bacteria
  - Sediments may act as reservoir/incubator = long-term source
  - Wetlands can act as source of *E. coli* and *Enterococcus* bacteria (wildlife is likely the source)
  - Risk to aquatic wildlife or humans unknown

SO WHAT??

Can these changes to wetland physical structure have a significant impact on wetland biota?

Exposure + $\boxed{\text{Ecological Effects}}$ = Ecological Risk

Impacts of Diverting Urban Runoff to Wetlands: Ecological Effects

Literature Inadequate on This Topic

- Habitat value of treatment wetlands typically documented by spp diversity & population counts
  - Indicates habitat attractiveness but not necessarily habitat quality
  - These indices do not reveal subtle effects such as:
    - Reproductive failure or low fledgling success
    - Weakened resilience from disease
    - Inappropriate nesting habitat
    - Lack of refuge from predators

Impacts of Diverting Urban Runoff to Wetlands: Ecological Effects

Literature Review Examined:

- Bioaccumulation and toxicity
- Impacts on habitat and species diversity
- Community structure and food web dynamics

Impacts of Diverting Urban Runoff to Wetlands: Bioaccumulation and Toxicity

- Plants and Algae
  - Contaminant exposure & bioaccumulation can result in:
    - Toxicity to plants and algae
    - Community shift to stress-tolerant species
    - Bioaccumulation and bioavailability to fauna
- Fauna (Invertebrates, fish, birds, amphibians, etc)
  - Documented cases where metals and organics bioaccumulate $\rightarrow$ toxicity
  - Potential for vulnerability for disease, stunted growth, decreased survival, changes in foundation of food web
  - Presence and severity of bioaccumulation and toxicity highly variable

Kesterson Marsh… Best Documented Science but Worst Case Scenario

- High (natural source) of selenium= extremely high contaminant loading rate
- Arid environment with high evapotranspiration rate = contaminants concentrated
- Wetland at terminus of irrigation – no outflow or dilution
- High concentration of wildlife

- Best documented case of links between exposure, bioaccumulation, and acute and chronic toxicity to wildlife
- Caution in proceeding with treatment wetlands… Harm to endangered species = Economic Liability

Impacts on Species and Habitat Type Diversity, Community Structure, and Trophic Level Dynamics

Cumulative effects of change in hydrology, sediment deposition, surface water and sediment chemistry:

- Fundamental changes in physical habitat eliminate areas typically used for breeding, forage, cover
- Changes in relative species abundance and diversity including:
  - Reduced native species
  - Increased exotic species
- Changes to community structure and food web including
  - Shift to stress-tolerant taxa (i.e. flood, pollutants, xs sedimentation, et al. disturbances)
  - Reduces or eliminates some lower food web guilds in favor of others (e.g. shredders versus collectors)

"Habitat May Be Attractive, but Not Have High Value"

Habitat Value of Treatment Wetlands

Habitat of treatment wetlands often fundamentally different than that of natural wetlands

- More uniform, predictable flows
- Less topographic complexity
- Lower plant species diversity (stress-tolerant plants with high uptake rates preferred)
- Altered plant community structure
- Regular disturbance associated with maintenance

- Need more data to quantify habitat value and evaluate risk to wildlife

Habitat Value of Treatment Wetlands on Landscape Scale

Southern California has lost 90% of wetland habitat…

- Increase in wetland acreage beneficial
- Often urban runoff only source of water for natural or constructed wetland
- Any new habitat, including treatment wetlands, will be extremely attractive to wildlife
- Treatment wetland acreage should not grow at expense of opportunities for natural wetland restoration and enhancement
- Installing treatment wetlands will improve natural wetland and aquatic habitat downstream!!

Ecological Effects: Summary

- Flow duration & magnitude
- Erosion/deposition processes
- Sediment grain size & topographic complexity
- H20 & sediment chemistry
- Bioaccumulation & toxicity in sensitive species
- Community composition & trophic structure
- Continuous disturbance associated with “maintenance”
- Severity of impact depends on site-specific factors
- Impact of treatment wetlands on landscape ecology should be considered

<u>MAGNITUDE OF EFFECTS IS NOT KNOWN</u>

Recommendations for Future Research

Two Fundamental Questions:

- **HOW EFFECTIVE ARE TREATMENT WETLANDS IN IMPROVING WATER QUALITY?**
- **DO TREATMENT WETLANDS POSE A SIGNIFICANT RISK TO WILDLIFE?**

Use Ecological Risk Assessment Paradigm…

Exposure + Ecological Effects = Ecological Risk

Address Research Gaps with Coordinated Research Program…

- Inventory treatment wetlands
  - ➢ Location
  - ➢ Basic design information
  - ➢ Monitoring performed
- Conduct baseline habitat survey
- Identify and prioritize research questions
- Initiate priority studies

Combining Urban Runoff Treatment and Wildlife Beneficial Use: Literature Recommendations to Mitigate Risk

- Landscape Planning
- Design Considerations
- Maintenance
- Long Term Monitoring and Adaptive Management

Considerations to Mitigate Risk of Urban Runoff to Wildlife: Landscape Planning

- Maximize water storage and infiltration opportunities to minimize urban runoff
- Several smaller decentralized treatment wetlands preferable to one large treatment wetland
- Locate treatment systems where there is no opportunity to restore historic or natural wetlands
- Installation of treatment wetlands should be coupled with an aggressive wetland and riparian restoration program
- Consider source control BMPs and treatment BMPs for improving the water quality of urban runoff before it enters natural wetlands and aquatic habitats

Considerations to Mitigate Risk to Wildlife: Treatment Wetland Design

- Conservative hydraulic and contaminant loading rates
- Source control and pretreatment recommended
- Design wetland such that primary treatment is provided in the forebay/initial pond and the remainder of the wetland is used for polishing and/or wildlife enhancement
- Where possible, design treatment wetland to provide habitat with a diversity of native species comparable to similar wetlands in the region
- Create gentle slope to allow for good plant establishment and diversity
- Design for moderate water level fluctuations

Considerations to Mitigate Risk to Wildlife: Treatment Wetland Maintenance

- Long-term, regular maintenance of treatment wetlands is critical to sustain treatment capacity and optimize the habitat value provided
- Maintenance can include:
  - Cleaning of pretreatment areas (dredge sediment forebays, trash removal, backwash sand filters, etc.)
  - Harvesting of plant biomass
  - Removal of exotic species & replanting of desired species
- Schedule maintenance work to avoid critical breeding and nesting periods for wetland species

Considerations to Mitigate Risk to Wildlife: Monitoring and Adaptive Management

- EPA recommends monitoring of the treatment wetlands to ensure that the system is functioning properly and not becoming an attractive nuisance to wildlife
- Monitoring data should be used to adaptively manage the treatment wetland, identify problems, improve performance, and enhance habitat value
- Consider long-term or at least periodic monitoring on older systems
- Develop a minimal set of monitoring requirements to document treatment wetland performance and habitat value

Do Treatment Wetlands Have a Role in Improving Water Quality and Providing Habitat in Southern California Landscape?

Yes, with….

- Siting, design and management criteria customized for So. Calif.’s arid climate and intensity and mix of land use
- Better understanding of how to minimize risk to wildlife and maximize habitat value

****Research – Standardized Monitoring-
Adaptive Management****

Questions, Comments?

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Ecol. Effects Assessment: Examples of Research Questions

- Most appropriate assessment endpoints to evaluate risk?
- How does biotic community composition/trophic structure compare between treatment vs. natural wetlands?
- Sensitivity of key plant or animal species to contaminant loading and accumulation?
- Bioaccumulation rates of contaminants at trophic levels?
- Toxicity observed in macroinvertebrates, fish, amphibians, or birds that live, forage, or breed in wetlands exposed to urban runoff?
- Habitat value of treatment wetlands on a landscape scale?

Exposure Assessment: Examples of Research Questions

- Wet and dry season loading rates by land use?
- Effluent quality of treatment wetlands in semi-arid climates under range of contaminant loading rates?
- Background concentrations of contaminants in the wetland surface waters in southern California?
- Effect of wet or dry season runoff on wetland: 1) physiochemical characteristics 2) sediment deposition rates, texture and grain size distribution, 3) hydrologic regime, and 4) storage and transport of contaminants?
- Maximum allowable change in hydrologic regime without deleterious effects to habitat values (by wetland class)?